Socio-scientific issues (SSI) are complex, sometimes controversial, social issues that revolve around scientific phenomena (Sadler, 2011); examples include climate change, antibiotic resistance, and genetically modified foods. Science instruction using an SSI-approach can have a positive impact on student learning of science content (Lewis & Leach 2006; Herman 2014; Sadler, Romine & Topcu, 2016), the nature of science (Eastwood, Sadler, Zeidler, Lewis, Amiri, & Zeidler, 2012; Khishfe & Lederman 2006; Zeidler et al. 2002;), and argumentation and reasoning skills (Romine, Sadler & Kinslow, 2017; Zohar & Nemet 2002; Zeidler et al. 2013). Overall, SSI-based instruction is an effective way for students to contextualize their science learning within a complex social context. While we know teachers plays an important role in enacting the SSI approach, shaping what is going on in the classroom, we know little about how
to support teachers for enacting SSI in a productive way. There has been limited research in the area, especially with respect to teacher learning about the implementation of the SSI approach in classroom settings.

Our research team has sought to address this research gap. We designed a professional development (PD) workshop to support teachers in co-designing SSI units. We then conducted follow-up interviews to understand what teachers learned about the SSI approach when they taught their units. In this study, we focus on teachers’ perspectives on the implementations of their co-designed SSI curricular units. The goal of the study is to identify ways in which teachers appropriate the SSI approach in their own classrooms and to better understand the factors and mechanism that may influence teacher’s appropriation. The findings of the study can inform the design of future PD. In particular, we ask the following research questions:

1. How do teachers appropriate the SSI approach as they engage in the co-design and enactment of SSI curricula?

2. What factors affect teacher appropriation of the SSI approach?

**Framework**

**Appropriation**

In this study, we use the construct of *appropriation*, rooted in sociocultural learning perspectives, to guide our inquiry about teacher learning with respect to appropriating the SSI approach. According to Grossman (1999), “appropriation refers to the process through which a person adopts the pedagogical tools available for use in particular social environments (e.g., schools, preservice programs) and through this process internalizes ways of thinking endemic to specific cultural practices” (p.15). It is important to unpack the two underlying constructs, “tools” and “internalization”, in this definition in order to better understand the process of appropriation.
Grossman (1999) distinguished between two types of pedagogical tools, conceptual and practical tools. While conceptual tools refer to principles, framework, or theories that guide a teacher’s instructional decisions, practical tools are those classroom practices and resources that “have more local and immediate utility.” In our study, the tools teachers aim to appropriate is the SSI approach, which is both conceptual and practical as we provided teachers with both the SSI-Teaching and Learning Framework and specific templates and teaching resources.

Internalization was a key process in Vygotsky’s developmental theory that he defined as “the internal reconstruction of an external operation” (1978, p. 56) gradually going from the interpsychological plane (between people) to the intrapsychological plane (within people). Consistent with the notion of internalization, Grossman argued that the “extent of appropriation depends on the congruence of a learner's values, prior experiences, and goals with those of more experienced or powerful members of a culture” and “through the process of appropriation, learners reconstruct the knowledge they are internalizing, thus transforming both their conception of the knowledge and, in turn, that knowledge as it is construed and used by others” (p.15).

We see the construct of appropriation as an appropriate fit for our inquiry because we view teachers as learners and we are interested in exploring the extent to which teachers take up the SSI approach and why. These questions of extent of appropriation and reasons underlying those trends are complex depending factors such as school settings, teacher’s personal goals and expectations for learning, and their views on SSI in particular. The construct provides a theoretical lens for us to think about the interactions between those factors and how they contribute to the teachers’ appropriation (or not) of the SSI approach.

Methods

Context
This study is part of a larger project in which 18 teachers participated in a 35-hour PD workshop in which they learned about teaching science through socio-scientific issues (Peel, Sadler, Friedrichsen, Foulk, & Kinslow, 2018). In the PD, teachers learned about the SSI Teaching and Learning Framework (Sadler, Foulk, & Friedrichsen, 2017), examined SSI units, heard first-hand accounts of SSI implementation from teachers, and were introduced to curriculum design scaffolds, such as a planning heuristic and an issue selection guide. The teachers then formed design teams of 2-3 members, and each team co-designed an SSI curriculum unit, resulting in a total of eight SSI curriculum units. The teachers were encouraged to implement their new units the following year in their classrooms.

Participants

In the school year the summer PD workshop, we contacted the 18 participants to track which teachers implemented their SSI units. Eight teachers were able to participate in the interviews and are the focus of this inquiry. Table 1 provides information about the participants including the topics of their co-designed SSI units and the science courses in which they implemented these units. The teachers are identified as early career (1-5 years teaching experience), mid-career (6-10 years), or veteran (10+ years).

Table 1. Participant Information

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Teaching Experience</th>
<th>Certification area</th>
<th>SSI Issue</th>
<th>Implementation Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tonya</td>
<td>Veteran</td>
<td>Chemistry,</td>
<td>Clean Water</td>
<td>Chemistry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmental Science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jess</td>
<td>Early career</td>
<td>Chemistry</td>
<td>Clean Water</td>
<td>Chemistry</td>
</tr>
<tr>
<td>Rebecca</td>
<td>Mid-Career</td>
<td>Biology</td>
<td>Junk Food Tax</td>
<td>Integrated Biology &amp; Literature, Biology</td>
</tr>
<tr>
<td></td>
<td>Mid-Career</td>
<td>Biology</td>
<td>Performance Enhancing Drugs</td>
<td>Anatomy &amp; Physiology</td>
</tr>
<tr>
<td>Margaret</td>
<td>Mid-Career</td>
<td>Biology</td>
<td>Performance Enhancing Drugs</td>
<td>Anatomy &amp; Physiology</td>
</tr>
<tr>
<td>Edward</td>
<td>Mid-Career</td>
<td>Biology</td>
<td>Performance Enhancing Drugs</td>
<td>Anatomy &amp; Physiology</td>
</tr>
</tbody>
</table>
Methodology

This is an interpretive case study (Merriam, 2001) of eight secondary science teachers who implemented a co-designed SSI unit in their classrooms. We conducted one-hour post-implementation, interviews based on a semi-structured interview protocol. The interview transcripts served as the primary data source. In addition, we also used semi-structured interviews conducted immediately following the summer PD as well as the teachers’ SSI units (design products and instructional materials) as secondary data sources to further explore themes that emerged in the post-implementation interviews.

The data analysis process included multiple coding rounds of the interview transcripts (Miles, Huberman & Saldaña, 2013). In the first round of analysis, we coded the interview transcripts using four deductive codes (e.g., views on SSI, school supports, challenges, and salient outcomes). The research team met and reached consensus on the coding for all eight teachers. In the second round of analysis, the data were coded inductively within each category. For example, inductive codes within the category, challenges, included: time constraints, enacting scientific practices, assessing student learning, making connections between issues and science content, and keeping up the same pace with co-workers.

The preliminary analysis suggested that there were multiple participants who shared the same inductive codes across the four categories. The research team decided to use a profile analysis approach to further reveal the patterns. First, the eight teachers were classified into three groups based on coding patterns from the initial analyses. We then unpacked, combined, or modified the initial inductive codes to better reflect the ideas and patterns evident in the teacher
groups. Next, we developed rich descriptions of each of the groups of teachers (i.e., profiles). In addition, we used the post-PD teacher interviews as a supplementary data source to see if there was additional evidence to support or reject our claims about the profiles and their features.

**Findings**

In this section, we present our findings with respect to how participant teachers appropriated the SSI approach as they enacted co-designed SSI units. In order to effectively describe teachers’ diverse approaches and perspectives on SSI while simultaneously highlighting the similarities among multiple participants, we developed profiles to capture the views and enactments of SSI shared by a group of participants. All of the participant teachers were positioned within one of the three profiles, which emerged from careful analyses of the interview data. We used the following labels to describe the profiles: *Embracer, Explorer, and Dismisser*, The salient features for each of the profiles and representative interview excerpts are presented in Table 2.

<table>
<thead>
<tr>
<th>Profile</th>
<th>Salient Feature</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Embracer</strong></td>
<td>Participant teachers foregrounded the social aspects of the focal SSI</td>
<td>“Looking back, there were probably times where maybe I spent too much time on the socio-scientific issue and had to almost force myself to come back to the cellular energy stuff.” (Rebecca)</td>
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<td></td>
<td>Participant teachers prioritized issues being relevant to student life</td>
<td>“Before the kids didn’t see how it really connects to them and their real lives. This [The SSI approach] really gave it a platform where it was more relevant and the students seemed a lot more interested and engaged in the material.” (Suzanne)</td>
</tr>
<tr>
<td></td>
<td>Participant teachers had a primary goal of student using science to form opinions</td>
<td>“I want the kids to learn to think objectively and use science to motivate their opinion. I think a good issue doesn’t have a right or wrong answer. It’s up for debate. They [students] can use science to support their argument.” (Suzanne)</td>
</tr>
<tr>
<td><strong>Explorer</strong></td>
<td>Participant teachers enacted limited social dimensions of the SSI approach.</td>
<td>“To me, project-based learning was similar to this approach, but then the way that it was a little bit newer is we kept coming back to the social aspect of it and trying to tie in all the different social, political, but my topic was in PBL. I feel like we just did that...”</td>
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Table 2. Salient feature of each profile
<p>| | |</p>
<table>
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<th></th>
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<tbody>
<tr>
<td><strong>Participant teachers viewed the SSI approach as a stimulus for</strong></td>
<td>There’s an example of one kid. That kid actually was super</td>
</tr>
<tr>
<td><strong>student engagement and interest</strong></td>
<td>engaged in that unit and I thought he was going to be like</td>
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<tr>
<td><strong>Margaret</strong></td>
<td>perfect kid in my class this boy. Since we got into the second</td>
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<td></td>
<td>unit, his behavior has changed, full turn around to in a</td>
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<td></td>
<td>negative way. He went from almost like, I’d say 90, 95%</td>
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<tr>
<td></td>
<td>engagement during the Mars [SSI] unit to about 50, 40 during</td>
</tr>
<tr>
<td></td>
<td>this [non-SSI] unit.” (Judith)</td>
</tr>
<tr>
<td><strong>Participants viewed SSI through the lens of content</strong></td>
<td>“They [Students] accidentally discovered that plants have to</td>
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<td></td>
<td>have light to grow and people have to have light not because</td>
</tr>
<tr>
<td></td>
<td>we need the light ourselves but because we need to eat</td>
</tr>
<tr>
<td></td>
<td>animals and plants that need the light. They have</td>
</tr>
<tr>
<td></td>
<td>discovered the carbon cycle and the energy cycle on their own.</td>
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<tr>
<td></td>
<td>That SSI made teaching photosynthesis a one-day note session</td>
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<tr>
<td></td>
<td>versus almost five.” (Judith)</td>
</tr>
<tr>
<td><strong>Participant teachers did not appropriate much of the SSI</strong></td>
<td>“I don’t think it’s so much that I need to learn more about it.</td>
</tr>
<tr>
<td><strong>approach during enactment</strong></td>
<td>I think I just need more time to organize myself and put</td>
</tr>
<tr>
<td></td>
<td>everything in a specific set order. Like I said, I don’t think</td>
</tr>
<tr>
<td></td>
<td>it’s anything new for me.” (Tonya)</td>
</tr>
<tr>
<td><strong>Dismisser</strong></td>
<td>“One [issue] that I found at the beginning of the year was</td>
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<td></td>
<td>when I was doing significant figures there was an issue with</td>
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<tr>
<td></td>
<td>the Olympics – because the Olympics were going on – and how</td>
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<td></td>
<td>significant digits or why the pool length and the timing for</td>
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<tr>
<td></td>
<td>the Olympics, why sometimes they’re more specific than others</td>
</tr>
<tr>
<td></td>
<td>based off of significant figures.” (Jess)</td>
</tr>
<tr>
<td><strong>Participant teachers had a superficial understanding of SSI</strong></td>
<td>“I started using, just using all those words in our</td>
</tr>
<tr>
<td><strong>approach</strong></td>
<td>explanation. Fecundity was one I used. Injurious species and</td>
</tr>
<tr>
<td></td>
<td>just all of – as much as I could pop any of those words with</td>
</tr>
<tr>
<td></td>
<td>analogies I would do that.” (Jemma)</td>
</tr>
</tbody>
</table>

**Embracer**

Among all eight participant teachers, Rebecca and Suzanne were profiled as the  
**Embracers** of the SSI approach. We use the term **Embracer** to highlight that the teachers  
composing this profile embraced the vision of the SSI approach and took an active role in  
addressing the challenges associated with implementing SSI units within school contexts. Their  
commitments to the SSI approach were reflected in the selection of issues, the design and  
enactment of the curriculum, and their beliefs about teaching SSI and its impact on student  
learning. In particular, teachers making up this profile advocated SSI by foregrounding the social
aspects of the SSI approach. They held that issues should be relevant to student life and were determined to help students use science to form opinions a priority. We next present the four salient features of *Embracers* with illustrative interview excerpts.

**Participant teachers foregrounded the social aspects of SSI approach.** One of the main characteristics shared by the *Embracer* teachers was their emphasis on the social aspects of the SSI throughout their units. This is a key element of issue-based teaching and learning as it supports students in making the connection between issues and societal concerns. The prioritizing of the social aspects of the SSI approach also distinguishes *Embracer* teachers from their colleagues who either enacted minimal social aspects of the issue and focused mainly on the connection between issues and science ideas (i.e., *Explorer*) or those who introduced issues as an add-on for real-world applications of canonical knowledge (i.e., *Dismisser*).

When co-designing the units with partners, *Embracer* teachers highlighted the importance of anchoring SSI throughout the unit. They viewed it as a key premise of SSI curriculum development so that they did not “get too caught up in the content and not making it back to the social aspect of the issue.” For example, both Rebecca and Suzanne reflected on how they purposefully made their focal issues the centerpiece of the curriculum, as opposed to using it as a mere hook to attract students’ attentions at the beginning of the unit. A focus on this design principle is demonstrated in the following interview excerpt from Rebecca:

> I think the hard part is that, anytime I use some kind of issue, it’s so easy at the beginning to introduce it and to get them [students] hooked on it. We can talk about the social aspects of it and the controversial stuff, but it’s the stuff in the middle [that matters]. It’s like keeping that issue at the forefront of what we’re doing, and I have to just so purposefully create things that are connecting it back to that issue over and over. (Rebecca)

Similar to Rebecca’s comment, Suzanne mentioned in the post-PD interview that prior to the PD experience she had used issues in a limited way: “[I used issues] as an introduction lesson to peak student interest … never really made it something the whole unit is centered around.” It is interesting to note that this limited way of teaching SSI is exactly how some of her
colleagues in the other two profiles taught their co-designed units. In addition, Suzanne reflected on her transition in the post-implementation interview and attributed the shift to the PD program. She claimed that the PD helped her envision how to make the issue the centerpiece of a curricular unit and “took it to the next level.”

During the enactment, Embracer teachers foregrounded the social aspects of the SSI approach even when facing a number of challenges such as time limitations. In particular, they were able to address those challenges and adapt the curriculum as needed to maintain a focus on the social dimension. Unlike their colleagues, Embracer teachers took initiative in navigating constraints using a variety of resources and found ways to mitigate the difficulties. This tendency is demonstrated in the following excerpt:

I actually wasn’t able to do that [the culminating project] because I ran out of time since it was my last unit of the year and I had that flood week that I lost a week. I actually switched it up a little bit and I actually incorporated it on a test. So, what I did was they had a graphic organizer and I gave ‘em an article about the Valley Park levy and that there were people that had the opinion that it was too high and they had to look at the stakeholders so a lot of elements are still there. So, they looked at the stakeholders and then they evaluated two different claims. (Suzanne)

In the excerpt, Suzanne described how she adapted her culminating project that featured students discussing the SSI from different stakeholders’ perspectives into a test given the lack of instruction time. Similarly for Rebecca, while she was able to teach the full SSI unit with her honors class, it was impossible to do so with her regular biology classes as her school mandated a pacing scheme that kept her classes coordinated with other biology classes. Still, Rebecca managed to implement part of her SSI unit in her regular biology classes within the cellular energy unit where her students searched information online and formed opinions on the issue of fat taxes based on evidence.

**Participant teachers prioritized issues being relevant to student life.** With respect to the criteria of what makes a good issue, Embracer teachers emphasized the importance of choosing an issue that is not only related to student lives, but also something students care about and can
connect to. This particular view on issues differs from those held by other teachers who thought about issues as a way to introduce content or as a real-world application. In addition, Embracer teachers perceived that the relevance of the issue could contribute to student engagement and interest. The following interview excerpt expresses this line of thinking:

Relevant issues to me, if you pick something that they’re [students] not familiar with, they don’t tend to have a connection to it. So I really wanted to pick a local issue that I know that they see because I knew that they’d have more background knowledge in it and it would spark their curiosity a little bit more just because they could see that. (Suzanne)

Moreover, because of the perceived link between the relevancy and student engagement, during the enactment, teachers in this profile tended to adjust the original lesson plans to make it as relevant to student lives as possible in order to increase the level of student engagement. For example, Suzanne changed her approach for introducing the issue on flooding because she observed that students were not as invested as she expected in the introductory video originally selected, a Youtube video of flooding that took place in 1993. Instead, she took her students outside to the school grounds and investigated the surrounding watershed as an alternative start for the unit. She thought that it was a “much better hook” and students “realized things that were really relevant just around their own school and what they could do.”

Rebecca also made similar adjustments to her curriculum to promote student engagement. She moved her culminating project related to the soda tax passed in Philadelphia to the beginning of the unit as a debate so that students “got to weigh in at the beginning and they kept going back to the issue.” According to Rebecca, the change was “really engaging” and students were “more interested in it than she anticipated.” This again speaks to the teacher agency that Embracer teachers demonstrated – being able to adapt the curriculum in response to what actually happened in the classroom.

Aligned with this view on issues, teachers in this profile valued students making connections between science and everyday life in terms of student learning. The following
excerpt provides an example of the type of student learning *Embracer* teachers value in their classrooms:

> I just checked my email yesterday and I had one of my students email me a picture of him biking on the levy and they would come back after that flood with pictures on their phone showing me things that they saw that we had talked about. They were all sandbagging and everything and talking about what we learned in class that they saw in real life. So, it was pretty cool. (Suzanne)

**Participant teachers had a primary goal of students using science to form opinions.**

In terms of instructional goals, teachers composing the *Embracer* profile prioritized students being able to use science to develop their own positions on complex issues. The pattern is reflected in the following quote:

> What we ended up doing at the end was we wanted to open it up a little bit more so it wasn’t just [about] “should there be a fat tax?” So at the end they [students] wrote a policy statement and they got to choose what group are they representing. So they formed their opinion basically, and then they had to find evidence to support it. (Rebecca)

Not only did they make their instructional goal explicit, *Embracer* teachers also shared the practical strategies they saw as effective in reaching the goal. Both Rebecca and Suzanne pointed out in the interviews that, in order achieve the goal, the issues should be complex and debatable. According to Rebecca, “it [the issue] has to be more than meets the eye and it cannot be those questions where you can have a yes and no answer.” Pedagogically, both teachers used literacy practices such as debates to engage students in discussing the social and political aspects of the issues. They mentioned that they had benefited from working with English teachers who helped them not only see the importance of doing so, but also shared with them particular instructional strategies and resources to do so effectively. For instance, Suzanne taught in a school where a literacy initiative had been going on for the past four years and integrating literacy and science became “part of the classroom culture.” The following excerpts from Rebecca exemplifies *Embracer* teachers’ perspective on how science and literacy can be integrated and are in service to each other.
When I think back about this, this is totally the reason that I wanted to do that integrated course with an English teacher. When we started writing that class, it was being able to bounce ideas off someone that had a totally different perspective, and her perspective is this social and political perspective because that’s generally how you teach English to high school kids is give them these issues. So combining that with my [science] content, we just figured it out. It just became such a natural way to teach it where I’m no longer teaching these discrete facts. (Rebecca)

Furthermore, consistent with their primary teaching goal, Embracer teachers valued students forming their opinions about complex SSI based on evidence. In fact, both Rebecca and Suzanne mentioned that they saw some of the students changed their opinions on the issue as the unit unfolded. The pattern is reflected in the following excerpt.

So they really got into that [the issue], and they had different opinions from the beginning of that research to the end of that research. And so that was interesting. Any time you can get them thinking enough that they would actually change their opinion or change a position, that’s fantastic. (Rebecca)

**Explorer**

There are three teachers in this study, Judith, Harry, and Margaret, who we sorted into the Explorer profile. We use the term Explorer to capture that teachers composing this profile were willing to explore the SSI approach because of its potential benefits for student learning. The participant teachers making up this profile shared three main characteristics: (1) they enacted limited social dimensions of the SSI approach, (2) they viewed the SSI approach as a stimulus for student engagement and interest, and (3) they viewed the SSI approach through the lens of content. In the following section we present the three salient features with interview examples and our analyses.

**Participant teachers enacted limited social dimensions of the SSI approach.** Unlike their colleagues in the Embracer profile, Explorer teachers enacted limited social dimensions of the SSI approach for various reasons. Two participants (e.g., Judith and Harry) cited time as the biggest reasons why they did not implement the culminating project, in which students were supposed to synthesize their ideas and reasoning from not only the science perspective, but also from the social, economic, and political ones. The pattern contrasts with Embracer teachers who
managed to adapt their curriculum and instruction to address time constraints. The other teacher (e.g., Margaret), who did enact the culminating project, admitted that “the social aspects of it [the focal SSI] just went away” and it was more of a traditional science project at the end of a unit.

Another major reason why Explorer teachers did not focus on the social dimension of the SSI approach seemed to be related to their inexperience with this type of teaching. From analyses of the post-PD interviews, none of the Explorer teachers had any prior experience teaching SSI in their classrooms before the PD. They were also explicit about their instructional emphasis on the content knowledge (discussed more in the next feature), either because of their personal background (e.g., a science major degree) or the school environment in which they taught. One participant cited the school environment as a key factor that prevented him from emphasizing much about the social aspect in his instruction:

Our school culture is very traditional, very much direct instruction driven, kind of a no-nonsense approach. So it’s very difficult to have teachers say, “Okay, we’re going to look at this issue,” and then the students will say, “Well, this is a science class.” So, they’re going to be confused as to why we’re talking about certain aspects that aren’t necessarily science and nature. (Harry)

While “explorer” teacher did not end up teaching the social aspects of the SSI units, they all saw the value in bridging the science and social dimensions of SSI and understood what it could look like in the classroom. It is important to note that the recognition about the value of SSI distinguishes the Explorers from the Dimissers who did not enact the social aspects either, but mainly because of their superficial understanding of the SSI approach. The pattern is reflected in the following excerpt:

I was excited about the social/political connections because that is an area I have no experience in. I was a hard science major in college, so I had a very analytical scientific end of the spectrum. Stephanie [a teacher using SSI], and some of the leaders in this program are very sociopolitical end of the spectrum at global sociology perspective. Totally different, but those two things work hand in hand with any science, any decision-making process. I only had one side of it, so getting to develop that sociopolitical side has been really beneficial for me. (Judith)

In addition, two participant teachers in this profile planned to incorporate more social aspects the next year. Harry discussed in detail about how he would move the culminating
project to the beginning of the unit and make it a full debate about using performance-enhancing drugs for high school athletes from different stakeholders’ perspectives including athletes, school administrators, parents, and coaches. It is worth noting that the plan mirrors exactly how Rebecca, one of the “Embracer” teachers in this study, adapted her culminating project into a debate to promote student engagement. It appears that Harry is positioned to move from an Explorer towards the Embracer profile after the enactment of his co-designed SSI unit.

**Participant teachers viewed the SSI approach as a stimulus for student engagement and interest.** While Embracer teachers perceived the SSI approach as an effective way to help students form positions about complex SSI, Explorer teachers primarily viewed SSI as a stimulus for student engagement and interest. In the post-implementation interviews, all Explorer teachers provided vivid examples of observed changes in students’ attitudes and engagement towards science learning when they taught the SSI units. According to the teachers, students seemed more motivated and engaged to learn science than they were during the regular science units for which they took a more traditional science teaching approach. For example, students started to ask each other questions, contribute more to the whole-class discussion, and searched for ideas and answers on their own. The following excerpt illustrates the pattern:

> Those first couple of days it was actually very exciting. We had an initial argumentation where I set a series of statements about PEDs [Performance-Enhancing Drugs] that were on purpose ambiguous, and they [students] had to choose a side whether they agree or disagree, and that was a very interactive and very -- not heated, but very passionate response from the student population I hadn’t seen really all year. (Harry)

Unlike their Embracer colleagues who highlighted the relevance of issues to student life, Explorer teachers prioritized issues being interesting and engaging to students. It is important to note that an issue that students care about in their daily life does not necessarily mean that students would be interested in exploring it out of curiosity, and vice versa. However, as we discussed in the previous section, Embracer teachers were able to adapt instruction to make the issue both relevant to student life and engaging. In contrast, Explorer teachers put more emphasis
on increasing student interest and engagement than involving students in considering the social aspects of the issue. This is understandable because the primary instructional goals of the two types of teachers were different. While *Embracer* teachers aimed for students developing their own opinions on issues that have significant societal concerns, *Explorer* teachers mainly saw SSI as an engaging context for generating student interest in which students can better learn the science content knowledge (more on this in the following section). For example, Judith acknowledged that her unit about humans moving to Mars was not really around an SSI. Rather, she picked the topic because she believed that her students would be very interested in it based on her knowledge of the student population. She also cited student interest as the key to meaningful student learning, especially for some students whom she did not think she had “a chance reaching without some external motivation.”

**Participants viewed the SSI approach through the lens of content.** Teachers composing the *Explorer* profile, like most high school science teachers, had learning the key disciplinary knowledge as their primary instructional goal. In addition, they assumed the role and identity of a content specialist within the classroom community who “got the hard science down.” As such, when reflecting on the enactment of the co-designed SSI units, *Explorer* teachers discussed the benefits and challenges of the SSI approach through the lens of content. For example, Judith and Harry thought it was productive to use issues to introduce content knowledge, as illustrated by the following quote:

> I think it [the issue] did the job of talking about homeostasis. It was a good way to introduce the content. I think it depends on the class, the personnel and who is in it, but I think the issue does a good job of trying to explore the content of homeostasis. (Harry)

In addition, these teachers highlighted positive student learning outcomes as the result of implementing the SSI units. Judith reported that her students earned “significantly better” test scores on the same content test compared to the previous year when she taught the content (e.g., photosynthesis and cellular respiration) with a more traditional approach. For Harry, he noticed
that “the overall quality of student work was better” in the SSI unit. He also felt that “giving the social background were helpful” for students engaged in scientific practices.

Margaret shared a slightly different perspective on how her particular unit supported student learning of content; however, this perspective reinforces the Explorer view of the primacy of science content. She expressed concern that her issue might be “bad” because it did not cover enough of the content that she hoped students would learn in the unit. The following quote illustrates Margaret’s thinking:

Well, it seemed so broad that it was hard to pinpoint what I really wanted them [students] to get out of it. For example, we did a lab and I was like, ‘I want you guys to model how this drug affects the body and how it affects the homeostasis.’ While there are very many different avenues that they could have gone with that, I feel like scientifically, there might not have been enough in our lesson. (Margaret)

In the quote, besides the uncertainty towards the content coverage, Margaret also expressed concern about the open-endedness associated with the SSI approach, which was a concern shared by all three participant teachers in the profile. Instead of a critique of the SSI approach itself, Explorer teachers cited it as a key challenge in enacting SSI units as they recognized the potential benefits with the open-endedness for student learning. While they all mentioned that they needed to provide more specific guidance for certain activities in future enactments, in general, they viewed it as a challenge for which they did not have much support or resources to address.

This [SSI approach] was much more of an open-ended approach where we don't really know where the book's going because the conversation could lend itself to different directions and then we have to -- I have to -- the teacher adapts to that direction because the kids want to go and see. I think the hard part was letting them kind of have the autonomy but also guiding them enough to where they would be going in the right direction. That was very hard, that I’m not very good at it. (Harry)

One particular challenge Explorer teachers pointed out related to the open-endedness of the SSI approach is the assessment of student learning. For example, Harry felt that “it was really hard to assess consistently on SSI for grade’s sake, from a practical side,” especially with the
school administration “pushing for tons and tons of grades like every day.” Judith also changed her culminating project (e.g., a townhall meeting from different stakeholders) into an engineering design problem because it was “a lot more measurable”.

Dismisser

We classified Tonya, Jess, and Jemma as Dismissers who did not consider SSI worthy of centering units around, but as an add-on with real-world applications of disciplinary knowledge. Teachers composing this profile shared three salient features: (1) they did not appropriate much of the SSI approach during the enactment, (2) they had a superficial understanding of the SSI approach, and (3) they had a didactic view of science teaching and learning. We next present our analyses of the three salient features with illustrative interview excerpts.

**Participant teachers did not appropriate much of the SSI approach during the enactment.** The key characteristic shared by all Dismisser teachers was their minimal appropriation of the SSI approach. They did not enact any social dimensions of the SSI approach. This pattern was observed among the Explorer teachers as well; however, while Explorer teachers were cognizant of what the social dimension entailed, Dismisser teachers did not seem to recognize the potential to explore social dimensions of problems as a part of the SSI approach. One participant teacher, Jemma, thought that the social dimension of the SSI approach was related to the dynamics of student group work. She was also the only teacher in the Dismisser profile who implemented the culminating project. However, the project (e.g., students creating a website to exhibit their knowledge about invasive species) was similar to a more traditional final presentation where students displayed discrete facts and knowledge about the topic they had learned over the course of the unit.

Unlike teachers from both of the other profiles, Dismisser teachers did not center their units around issues. Rather, they introduced the issue as a context, mostly at the beginning of the
unit, to lead to the content knowledge they needed to cover. For example, Jess and Tonya, who were curriculum design partners, used the issue of water quality to introduce the concept of different types of matter (e.g., pure substances vs. mixtures) and separation techniques. As such, when implementing their SSI unit, 

**Dismiss**er teachers did not enact much of the SSI approach, but maintained their traditional ways of teaching science. It is interesting to note that, while Jess admitted that she “never really understand how to tie the issue and content together” and struggled with incorporating SSI in her classroom as a first-year new teacher, Tonya and Jemma both claimed that the SSI approach was something they had been doing for a long time. The following quote from Tonya illustrates this mindset:

> I think I’ve been doing this all along since I’ve started teaching. I always have tried to bring current events or issues into the classroom so the kids could understand. I just didn’t have a formal format to use. (Tonya)

**Participant teachers had a superficial understanding of the SSI approach.** Our interview analyses revealed that 

**Dismiss**er teachers’ minimal uptake of the SSI approach was connected to their superficial understanding of the approach, at least in part. **Dismiss**er teachers thought of issues only in terms of an application of content knowledge. According to them, anything in the media that has some sort of scientific principles behind them could serve as an issue. For instance, Tonya and Jess chose water quality as their issue partly because “it was in the news.” Also, when Jess was asked about her use of issues in other units, she cited the Olympics as an issue to talk about significant figures “because the Olympics was going on.” Based on this particular view of issues, it was not surprising that 

**Dismiss**er teachers did not consider issues as an anchoring piece in the SSI units. Instead, they saw issues more as an additional piece of the curriculum to help students make connections between scientific content and the outside world.

Similar to teachers in the **Explorer** profile, Jess and Jemma viewed SSI as a way to teach content. For instance, Jemma thought that using “invasive species” as the context could “hit a lot
of content.” Jess also deemed the purpose of doing SSI as “helping student learn the content.” Jess further argued that, issues should be selected for the topics that were challenging for students to learn in the first place. The following quote presents her line of thinking:

By making it more or choosing a unit that students struggle with and going from there, because I think that also could help, that’s why you want to do this [SSI], is to help student learning. Choosing a topic that feels challenging and then you choose an issue based off of that. (Jess)

It was this view on issues that contributed to Jess’s dissatisfaction with her SSI unit because “there were no challenging learning objectives and students could understand the content without it [issue].”

While all eight teachers noted that students were interested in the issue during the enactment, the ways in which they described that interest differed. In contrast to Embracer teachers and Explorer teachers who were enthusiastically giving examples of how students became invested in the issues more than they anticipated, Dismisser teachers talked about student interest at a surface level (e.g., “there were a lot of kids who were interested in the topic”). In addition, they mentioned little about how engaged students were in the SSI units (e.g., participating in the whole-class conversation), as compared teachers in the other two profiles. The pattern suggests that Dismisser teachers did not see SSI as a stimulus for student engagement and interest.

Participant teachers had a didactic view of science teaching and learning. One main feature shared by Dismisser teachers is their didactic view of science teaching and learning. In particular, their pedagogical approaches were teacher-centered in nature. For example, Jemma used lecture as her primary teaching method. She noted in the interview that, “when students were on computers searching information, you can sit and lecture to them for about 20 minutes whereas before I could have students stick with for almost an hour.” Jess, who was a first-year teacher, expressed her struggle with teaching SSI due to her didactic teaching method. She said it was “hard to teach in a different way” because she learned science in this way. All three teachers
in the \textit{Dismisser} profile reported the instructional steps they went through during instruction, in which students had little autonomy to guide their own science learning. The following excerpt provides an example of the procedural nature of \textit{Dismisser} instruction:

We talk about matter as a whole, and then I try and make sure they [students] understand the breakdown of matter is broken up into two distinct categories of pure substances, and then mixtures. Then we'll branch the pure substances off into elements and compounds. They're giving – I'm giving them definitions, but I want to make sure they understand the definitions. So that's why I ask them to show me examples of what we're talking about. Then again the mixtures will branch off into the homogeneous or heterogeneous mixtures, and then they give me those examples and definitions. (Tonya)

In addition to the teacher-centered pedagogical approach that featured intensive lecturing, \textit{Dismisser} teachers also tended to prioritize learning vocabulary and discrete scientific facts. For instance, Jemma noted that she emphasized vocabulary learning a lot in her science classroom, and she tried to use big words such as “fecundity” and “injurious species” when she explained things to her students.

In terms of student learning, consistent with their didactic view of science teaching, \textit{Dismisser} teachers valued students memorizing discrete scientific knowledge. Jemma commented in the interview that she was not satisfied with her students because they were unable to remember some specific information about invasive species. Similarly, the following excerpt from Jess focused on student learning of scientific information:

I think the students found it very interesting, I think they definitely took a lot away from it because during the formative that I gave I was like, “What did you learn about dirty water?” A lot of them had interesting facts that they put. They definitely retained that information about the issue. (Jess)

We argue that, because of this didactic view of science teaching and learning, \textit{Dismisser} teachers could not see the value of the SSI approach (e.g., increase student engagement and student interest, students developing opinions on complex issues).

\textbf{Patterns across Profiles}
In addition to the unique features that characterize each teacher profile, we also found patterns common among teachers across profiles. By looking at those patterns, we hope to have a better understanding of teachers’ appropriation of the SSI approach that was not adequately captured by the profile analysis. In particular, we present in this section two major challenges participant teachers noted as they implemented the co-designed SSI units.

**Lack of instructional time.** Among all the participant teachers in this study, seven out of eight teachers cited a lack of instructional time as one of the biggest challenges associated with implementing the SSI units. Jemma, the only teacher who did not see time as a constraint acknowledged that she had “a lot of autonomy” in terms of her teaching schedule. For those teachers who did view time as a major impediment, they were not able to finish the units as they planned for various reasons. Both Judith and Rebecca attributed the lack of instructional time to their accommodations to students taking an active role in investigating the issues. According to them, they ran out of time partly because students were eager to explore the issues themselves in different activities such as searching information online about the issues, discussing the issues with peers, and constructing models to illustrate the science behind the issues. Another reason why teachers fell short of time when implementing the SSI units might be related to the diversity of student population. Suzanne and Judith noted that they had to slow their pace to meet their students’ learning needs, which they had little knowledge about when they designed the unit. For instance, Suzanne had many Individualized Education Program (IEP) students in her class who “loved the unit,” but “just took longer to read and get through the concept.” Judith also mentioned that she had one class half of which were IEP students and “it just took longer.” Furthermore, while teachers might need to balance covering the curriculum materials and promoting student learning as they enacted the SSI units, they may also have to deal with the pressure to keep the same pace with their co-workers imposed by the school administration.
Tonya, Jess, and Rebecca all claimed that they were not able to finish the units as planned due to the perceived pressure of lagging behind their colleagues. The following quote from Tonya provides an example of this line of thinking:

Unfortunately, I didn’t get the position paper and I did not get my culminating activities, just because I was getting too far behind my other co-workers on their units. We just didn’t get to that. It was tough. I think I just probably put a little too much into the unit. (Tonya)

**Engaging students in scientific practices.** The other primary challenge that the majority of the participant teachers perceived was related to engaging students in scientific practices as described in the NGSS. Among all the participants, four teachers found it challenging to engage students in modeling to investigate the issues. The perceived challenges ranged from helping students recognize the purpose of modeling, to figuring out the technical aspects of a computer-based simulation, and to providing appropriate scaffolds to support students in developing their model-based explanations. The following quote by Margaret provides an example of the challenges associated with engaging students in modeling practices.

I had them [students] model, "what are the effects of this drug," just in general and they drew a model and drew the parts of the body that it affected. And then when we got some feedback, that was our modifying the model, I think my students got lost in that. They got stuck. I think I just dove in too quick and didn't give them small enough steps to do it as they went. (Margaret)

In addition to modeling, using evidence to construct arguments was also identified as challenging for students as they explore the issues. For example, Suzanne, whose school had adopted an NGSS approach in teaching science, tried to incorporate multiple scientific practices in her SSI units. When reflecting on her experience combining the NGSS practices with SSI, Suzanne pointed out that the most challenging practice for her students was connecting the evidence they collected from the labs to their overall argument about the complex issue of flooding. Suzanne further suggested that scaffolding strategies that highlight this aspect of argumentation practice might be useful to address the challenge.

**Discussion and Implication**
The findings of this study suggest that, the difference between the three profiles fall into the following three dimensions, 1) teachers’ balance between content and the social dimension of the SSI approach, 2) teachers’ instructional goals for science teaching and learning, and 3) teachers’ views on the SSI approach. In addition, in each dimension, the salient features of different profiles tended to fall onto a continuum that indicate a teacher learning trajectory towards the full appropriation of the SSI approach. For example, in terms of the balance between content and the social dimension of the SSI approach, while Embracer teachers were proficient in attending to both dimensions, Explorer teachers mainly focused on the content dimension. In contrast, Dismisser teachers were resistant in incorporating both dimensions and maintained their traditional science teaching style. Similarly, in terms of instructional goals, whereas Embracer teachers prioritized students forming their own opinions based on science, Explorer teachers focused on key disciplinary knowledge learning, and Dismisser emphasized learning about vocabulary and discrete facts about science. Furthermore, the analyses of the interviews indicate that teachers may be able to transition through the trajectory profiles. For instance, in reflecting on how their practices evolved following the PD workshop in contrast to their previous teaching experiences the two Embracer teachers, Rebecca and Suzanne, seemed to suggest that they had likely adopted Explorer teacher stances prior to the workshop. In their past experiences, they had used issues as a hook to peak student interest and engagement as opposed to centering the unit around issue and constantly revisiting the social dimension of the issue throughout the unit. Also, Rebecca noted in her interview that while she might spend too much time on the social dimension of the unit, she used to be “the other way around”, similar to Explorer teachers.

So what does this hypothetical teacher learning trajectory mean for future professional development aiming to support teachers in better enacting the SSI approach? Similar to the work that has been done in the area of learning progressions, by identifying the features that
characterize the ways in which teachers appropriate the SSI approach through empirical validation, we may have a better understanding of how to help teachers move from one profile to another. For example, the results of this study suggest that *Embracer* teachers had extensive experience working with English/literacy teachers that seemed to help them recognize the importance of discussing the social dimension of issues as well as how to do so effectively in the classroom. Therefore, it may be productive for future PD to consider pairing science teachers with English/literacy teachers to co-design units and/or helping teachers to find collaborating English teachers to co-teach the unit.

**References**


